(19)日本国特許庁（ＪＰ）

(12) 公開特許公報(A)

(11)特許出願公開番号
特開2000－321135
(P2000－321135A)

(43)公開日 平成12年11月24日(2000.11.24)

(51)Int.Cl.7	識別記号	ＦＩ	テーマコード゛(参考)
Ｇ０１Ｊ 3/18		Ｇ０１Ｊ 3/18	２Ｇ０２０

審査請求 未請求 請求項の数３ ＯＬ （全 ７ 頁）

(21)出願番号 特願平11－126760

(22)出願日 平成11年５月７日(1999.5.7)

(71)出願人 000006507
横河電機株式会社
東京都武蔵野市中町２丁目９番32号

(72)発明者 鈴木 泰幸
東京都武蔵野市中町２丁目９番32号 横河電機株式会社内

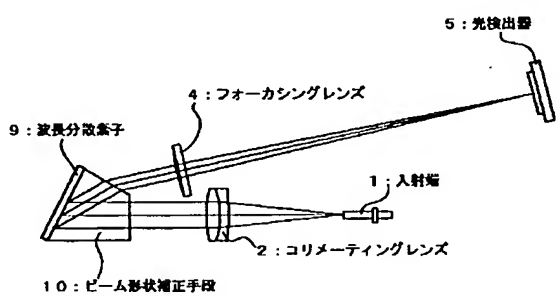
(72)発明者 三瓶 義広
東京都武蔵野市中町２丁目９番32号 横河電機株式会社内

(72)発明者 岡田 頼樹
東京都武蔵野市中町２丁目９番32号 横河電機株式会社内

Ｆターム(参考) 2G020 CB21 CC01 CC02 CC63 CD24

(54)【発明の名称】 分光装置

(57)【要約】
【課題】 対湿性及び温度特性の改善が可能な分光装置を実現する。
【解決手段】 波長分散素子を用いた分光装置において、入射光を平行光にするコリメーティングレンズと、波長分散素子と、この波長分散素子と一体化されコリメーティングレンズからの平行光を波長分散素子に入射し、波長分散素子の出射光を屈折させて出射するビーム形状補正手段と、このビーム形状補正手段の出力を集光するフォーカシングレンズと、このフォーカシングレンズの出力光を検出する光検出器とを設ける。



【特許請求の範囲】

【請求項1】波長分散素子を用いた分光装置において、
入射光を平行光にするコリメーティングレンズと、
波長分散素子と、
この波長分散素子と一体化され前記コリメーティングレンズからの前記平行光を前記波長分散素子に入射し、前記波長分散素子の出射光を屈折させて出射するビーム形状補正手段と、
このビーム形状補正手段の出力を集光するフォーカシングレンズと、
このフォーカシングレンズの出力光を検出する光検出器とを備えたことを特徴とする分光装置。

【請求項2】前記波長分散手段が、
回折格子であることを特徴とする請求項1記載の分光装置。

【請求項3】前記ビーム形状補正手段が、
プリズムであることを特徴とする請求項1記載の分光装置。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、波長分散素子を用いた分光装置に関し、特に対環境性及び温度特性の改善が可能な分光装置に関する。

【0002】

【従来の技術】従来の分光装置では入射光を波長分散素子である回折格子等に照射して波長分散された光を光検出器で受光することにより波長毎に光を分離して検出するものである。

【0003】図4はこのような従来の分光装置の一例を示す構成図である。図4において1は外部から光源の出力光、若しくは、光ファイバからの出射光が入射される入射端、2はコリメーティングレンズ、3は回折格子等の波長分散素子、4はフォーカシングレンズ、5はフォトダイオードアレイ等を用いた光検出器である。

【0004】入射端1からの出力光はコリメーティングレンズ2により平行光に変換されて波長分散素子3に入射される。波長分散素子3からの波長分散された光はフォーカシングレンズ4により集光されて光検出器5に入射される。

【0005】また、図5は波長分散素子3である回折格子の一例を示す構造断面図である。図5において6はガラス等で形成される基板、7は回折を生じさせるための格子が多数設けられた樹脂のレプリカ、8は金属の反射膜である。

【0006】基板6上には多数の格子が設けられた樹脂のレプリカ7が形成され、レプリカ7の表面には反射膜8により覆われている。

【0007】ここで、図4に示す従来例の動作を説明する。回折格子等の波長分散素子3に入射された光はその波長により回折角が異なるので、それぞれ異なる方向に回折光として出射され、フォーカシングレンズ4により光検出器5を構成する各受光素子にそれぞれ集光される。

【0008】例えば、図4中”FP01”、”FP02”及び”FP03”に位置する受光素子では異なる波長の光が集光される。図6に示す従来例では回折格子等の波長分散素子3を回転させる必要がないので高速性及び信頼性に優れている。

【0009】例えば、回折格子等の波長分散素子3の回折の次数を”m”、回折格子等の波長分散素子3の格子定数を”d”、回折格子等の波長分散素子3への入射角及び出射角を”i”及び”θ”、波長を”λ”とすれば、

$$m\lambda / d = \sin i + \sin\theta \qquad (1)$$

となる。

【0010】図4に示すような分光装置をWDM（Wavelength Division Multiplxing：波長多重信号）システム監視モニタ等のように狭い波長範囲を扱うように設計した場合にはフォーカシングレンズ4の焦点距離と比較して波長分散による光路の広がりが小さくなり、光検出器5として1次元配列のフォトダオードアレイを用いた時の各素子の位置と出射角はほぼ比例関係になる。

【0011】但し、波長と出射角との関係は式（1）を微分した、

$$d\lambda / d\theta \,|_{i} = (d / m) \cdot \cos\theta \qquad (2)$$

となる。

【0012】式（2）から分かるように波長と分散角は出射角の余弦に比例することになる。この出射角は分光装置の波長範囲、用いる回折格子の格子定数及びフォーカンシングレンズ4の焦点距離等を用いて式（1）から求めることができる。

【0013】図6はこのような分光装置の一設計例を示す表であり、図7は各波長に対する出射角を示す表である。この場合、例えば、”λ＝1．55［μm］”、”格子本数900［1／mm］”及び”32［nm］”の波長範囲で”190個”の受光素子とすれば、平均波長分散は”32／190＝約0．17［nm］”となる。

【0014】また、コリメーティングレンズ2として焦点距離f2が”50mm”のものを用いると回折格子等の波長分散素子3の使用領域は入射端1の開口数及び波長分散素子3への入射角で決まり、”11．1［mm］”の長軸の楕円となる。

【0015】Reileigh基準による理論分解能”λ／Δλ”は波長分散素子3である回折格子の総溝本数で求まるので”

$$900 \times 11.1 \fallingdotseq 10000 \qquad (3)$$

であり、

$$\lambda / \Delta\lambda = 1.55 / \Delta\lambda = 10000 \qquad (4)$$

$$\therefore \Delta\lambda = 1.55 / 10000 \fallingdotseq 0.15\,[\mathrm{nm}] \qquad (5)$$

となる。

【００１６】また、結像の大きさ”ω”は、回折光のビーム幅を”３．４［ｍｍ］”、フォーカシングレンズ４に入射する光の半径と焦点距離との比を”ＮＡ”とすれば、

$$\omega = 2 \cdot \lambda / (\pi \cdot \mathrm{NA}) \qquad (6)$$

となる。

【００１７】式（６）から結像の大きさは”５９［μｍ］”なり、分解能は平均波長分散”０．１７ｎｍ／５０μｍ”との積で”０．２［ｎｍ］”となり、理論分解能“Δλ＝０．１５［ｎｍ］”をやや下回り適切な値となる。

【００１８】

【発明が解決しようとする課題】しかし、図４に示す従来例では式（５）から分かるように分解能は回折格子等の波長分散素子３で使用される領域の大きさに依存しているため、分解能を向上させるためには光学系を構成する光学部品を小さくすることが困難であり、装置の小型化が困難であると言った問題点があった。

【００１９】また、図５に示すように波長分散素子３である回折格子のレプリカ部分はガラス等だけによって形成されているレンズやプリズムのような光学部品と比較して対湿性が劣ると言った問題点があった。

【００２０】さらに、図５に示す回折格子を空気中で用いる場合には、空気の屈折率を”n_{air}”、温度を”Ｔ”、回折格子の格子定数を”Ｄ”、波長を”λ”とすると、その出射角”θ”の温度特性は、

$$d\theta/dT = -\lambda / (D \cdot \cos\theta) \times \{dD/(D \cdot dT) + (1/n_{air})(dn_{air}/dT)\} \qquad (7)$$

となる。

【００２１】式（７）において”｛｝”内の第１項は波長分散素子３である回折格子の線膨張係数であり、第２項は空気の屈折率の温度係数である。また波長の温度係数は、

$$d\lambda/dT = (d\lambda/d\theta) \cdot (d\theta/dT) = -\lambda \cdot \{dD/(D \cdot dT) + (1/n_{air})(dn_{air}/dT)\} \qquad (8)$$

となる。

【００２２】例えば、波長を”１．５５μｍ”としてパイレックスガラスを基板６とした回折格子を空気中で使用するとその温度係数は”約３．７ｐｍ／℃”となる。すなわち、分光装置の波長特性は回折格子の材料の線膨張係数に起因する温度特性を有すると言った問題点があった。従って本発明が解決しようとする課題は、対湿性及び温度特性の改善が可能な分光装置を実現することにある。

【００２３】

【課題を解決するための手段】このような課題を達成するために、本発明のうち請求項１記載の発明は、波長分散素子を用いた分光装置において、入射光を平行光にするコリメーティングレンズと、波長分散素子と、この波長分散素子と一体化され前記コリメーティングレンズからの前記平行光を前記波長分散素子に入射し、前記波長分散素子の出射光を屈折させて出射するビーム形状補正手段と、このビーム形状補正手段の出力を集光するフォーカシングレンズと、このフォーカシングレンズの出力光を検出する光検出器とを備えたことにより、回折格子表面のレプリカにはプリズム等のビーム形状補正手段が設けられるので耐湿性が改善されることになる。

【００２４】また、波長分散素子の出射光をビーム形状補正手段で補正することにより、波長分散素子の出射角の余弦成分に起因する非線形性がビーム形状補正手段の余弦成分による非線形性で補償されることになり、波長分散特性の平坦化が可能になる。また、波長分散素子とビーム形状補正手段を一体化した場合の温度係数をビーム形状補正手段の入射面での屈折による温度係数で補正することにより、温度特性の改善が可能になる。さらに、プリズム等のビーム形状補正手段の媒質の屈折率を大きくすることにより、波長分解能を犠性にすることなく分光装置の小型化が可能になる。

【００２５】請求項２記載の発明は、請求項１記載の発明である分光装置において、前記波長分散手段が、回折格子であることにより、回折格子表面のレプリカにはプリズム等のビーム形状補正手段が設けられるので耐湿性が改善されることになる。また、波長分散素子の出射光をビーム形状補正手段で補正することにより、波長分散素子の出射角の余弦成分に起因する非線形性がビーム形状補正手段の余弦成分による非線形性で補償されることになり、波長分散特性の平坦化が可能になる。また、波長分散素子とビーム形状補正手段を一体化した場合の温度係数をビーム形状補正手段の入射面での屈折による温度係数で補正することにより、温度特性の改善が可能になる。さらに、プリズム等のビーム形状補正手段の媒質の屈折率を大きくすることにより、波長分解能を犠性にすることなく分光装置の小型化が可能になる。

【００２６】請求項３記載の発明は、請求項１記載の発明である分光装置において、前記ビーム形状補正手段が、プリズムであることにより、回折格子表面のレプリカにはプリズム等のビーム形状補正手段が設けられるので耐湿性が改善されることになる。また、波長分散素子の出射光をビーム形状補正手段で補正することにより、

波長分散素子の出射角の余弦成分に起因する非線形性がビーム形状補正手段の余弦成分による非線形性で補償されることになり、波長分散特性の平坦化が可能になる。また、波長分散素子とビーム形状補正手段を一体化した場合の温度係数をビーム形状補正手段の入射面での屈折による温度係数で補正することにより、温度特性の改善が可能になる。さらに、プリズム等のビーム形状補正手段の媒質の屈折率を大きくすることにより、波長分解能を犠牲にすることなく分光装置の小型化が可能になる。

【００２７】

【発明の実施の形態】以下本発明の実施の形態を図面を用いて詳細に説明する。図１は本発明に係る分光装置の一実施例を示す構成図である。図1において１，２，４及び５は図４と同一符号を付してあり、９は回折格子等の波長分散素子、１０はプリズム等のビーム形状補正手段である。

【００２８】入射端１からの出力光はコリメーティングレンズ２により平行光に変換されプリズム等のビーム形状補正手段１０を介して回折格子等の波長分散素子９に入射される。回折格子等の波長分散素子１０からの回折光は再びビーム形状補正手段９を介してフォーカシングレンズ４により集光されて光検出器５に入射される。

【００２９】ここで、図1に示す実施例を図２を用いて説明する。図２は波長分散素子９及びビーム形状補正手段１０での光路を説明する説明図であり、図２中”ＩＬ０１”は入射光、”ＯＬ０１”は出射光である。また、基本的な動作は図６に示す従来例と同様であるので説明は省略する。

【００３０】図5に示したように回折格子の表面のレプリカにはプリズム等のビーム形状補正手段が設けられるので耐湿性が改善されることになる。＊

＊【００３１】また、分光装置の波長分散特性は式（２）で求められこれを変形すると、

$d\lambda=(d/m)\cdot\cos\theta\cdot d\theta$　（９）

となり、光検出器５を構成する受光素子が等間隔であるとすると余弦成分（ｃｏｓθ）に起因して波長分散に不均一が生じることなる。言い換えれば、非線形性が存在する。

【００３２】一方、屈折の式は媒質の屈折率を”n_1”及び”n_2”、入射角及び出射角を”φ”及び”ψ”とすると、

$n_1\cdot\sin\phi=n_2\cdot\sin\psi$　（１０）

となり、”φ”で微分すると、

$n_1\cdot\cos\phi\cdot d\phi=n_2\cdot\cos\psi\cdot d\psi$　（１１）

となる。

【００３３】式（１１）から分かるように屈折角もまた余弦成分に依存する。従って、波長分散素子９の出射角の余弦成分に起因する非線形性を屈折（ビーム形状補正手段１０）の余弦成分による非線形性で補償することが可能になる。

【００３４】図２において波長分散素子９の入射角及び出射角を”θ_1”及び”θ_2”、ビーム形状補正手段１０の入射角及び出射角を”θ_3”及び”θ_4”とし、ビーム形状補正手段１０の屈折率を”ｎ”、波長を”λ”とすれば、

$\sin\theta_1+\sin\theta_2=\lambda/(n\cdot d)$　（１２）

$d\theta_2/d=-d\theta_3/d\lambda$　（１３）

$n\cdot\sin\theta_3=\sin\theta_4$　（１４）

となる。

【００３５】そして、式（１２）から式（１４）を微分して整理することにより平均波長分散が得られ、＊

$$d\theta_4/d\lambda-\cos\theta_3/(d\cdot\cos\theta_2\cdot\cos\theta_4)\qquad(15)$$

となる。※

※【００３６】さらに、式（１５）を変形して、

$$\begin{aligned}d^2\theta_4/d\lambda^2=&(d\theta_4/d\lambda)^2\\&\times\{\sin\theta_4/\cos\theta_4\\&-(\sin\theta_2\cdot\cos\theta_4)/(n\cdot\cos\theta_2\cdot\cos\theta_3)\\&-(\sin\theta_3\cdot\cos\theta_4)/(n\cdot\cos^2\theta_3)\}\qquad(16)\end{aligned}$$

となる。

【００３７】ここで、この特性が線形であるためには、”$d^2\theta_4/d^2=0$”であるから、式（１６）を変形して、

$\tan\theta_3/(1-n^2\cdot\sin^2\theta_3)$
$=n\cdot\tan\theta_2/(n^2-1)$　（１７）

となる。

【００３８】この結果、波長分散素子９の出射光をビー★

★ム形状補正手段１０で補正することにより、波長分散素子９の出射角の余弦成分に起因する非線形性がビーム形状補正手段１０の余弦成分による非線形性で補償されることになり、波長分散特性の平坦化が可能になる。

【００３９】また、ビーム形状補正手段１０であるプリズム等の媒質の屈折率にも温度係数が存在するので、媒質の空気に対する温度係数の相対値を”n_r”、絶対値を”n_a”とし、空気の屈折率を”n_{air}”とすれば、

$$n_r=n_a/n_{air}\qquad(18)$$

$$(1/n_r)(dn_r/dT)=(1/n_a)(dn_a/dT)-(1/n_{air})(dn_{air}/dT)\qquad(18)$$

$$n_{air}\fallingdotseq1,\ n_r\fallingdotseq n_a$$

と表される。☆

☆【００４０】波長分散素子９とビーム形状補正手段１０

を一体化した場合の温度係数を図3を用いて説明する。図3は波長分散素子9及びビーム形状補正手段10での光路を説明する説明図である。図3中”IL12”及び”IL22”は入射光、図3中”OL12”及び”OL22”は出射光であり、図3(A)は入射光”IL21”がビーム形状補正手段10の表面で図3表面に対して時計回り屈折する場合を、図3(B)は入射光”IL22”がビーム形状補正手段10の表面で図3表面に対して反時計回り屈折する場合ををそれぞれ示している。

【0041】図3(A)の場合、入射光”IL12(若しくは、”IL22”)”のビーム形状補正手段10に対する入射角を”θ_i”、ビーム形状補正手段10の入射光”IL12(若しくは、”IL22”)”の屈折角を”θ_0”、波長分散素子9への入射角を”θ_1”、波長分散素子9における回折角を”θ_2”、出射光”OL12(若しくは、”OL22”)”が出射されるビーム形状補正手段10の出射面への回折光の入射角を”θ_3”、そして、前記出射面での屈折角を”θ_4”とすれば、

$$n_r \cdot \sin\theta_0 = \sin\theta_i \qquad (19)$$

$$d\theta_0 = d\theta_1 \qquad (20)$$

$$\sin\theta_1 + \sin\theta_2 = \lambda/(d \cdot n_a) \qquad (21)$$

$$d\theta_2 = -d\theta_3 \qquad (22)$$

$$n_r \cdot \sin\theta_3 = \sin\theta_4 \qquad (23)$$

となる。

【0042】式(19)～式(23)を温度”T”で微分すれば、

$$(dn_r/dT) \cdot \sin\theta_0 + n_r \cdot \cos\theta_0 \cdot (d\theta_0/dT) = 0 \qquad (24)$$

$$d\theta_0/dT = d\theta_1/dT \qquad (25)$$

$$\cos\theta_1 \cdot (d\theta_1/dT) + \cos\theta_2 \cdot (d\theta_2/dT) = -\lambda/(d \cdot n_a) \times \{(1/d)(dd/dT) + (1/n_a)(dn_a/dT)\} \qquad (26)$$

$$d\theta_2/dT = -d\theta_3/dT \qquad (27)$$

$$(dn_r/dT) \cdot \sin\theta_3 + n_r \cdot \cos\theta_3 \cdot (d\theta_3/dT) = \cos\theta_4 \cdot (d\theta_4/dT) \qquad (28)$$

となる。

【0043】式(24)～式(28)を整理すると、

$$\begin{aligned} d\theta_4/dT &= (\sin\theta_3/\cos\theta_4)(dn_r/dT) \\ &\quad + (n_r \cdot \cos\theta_3/\cos\theta_4)(d\theta_3/dT) \\ &= (\sin\theta_3/\cos\theta_4)(dn_r/dT) \\ &\quad - (n_r \cdot \cos\theta_3/\cos\theta_4) \\ &\quad \times [-\lambda/(d \cdot n_a)(1/\cos\theta_2) \\ &\quad \times \{(1/d)(dd/dT) + (1/n_a)(dn_a/dT)\} \\ &\quad - (\cos\theta_1/\cos\theta_2)(d\theta_1/dT)] \\ &= (\sin\theta_3/\cos\theta_4)(dn_r/dT) \\ &\quad + \lambda \cdot \cos\theta_3/(d \cdot \cos\theta_2 \cdot \cos\theta_4) \\ &\quad \times \{(1/d)(dd/dT) + (1/n_a)(dn_a/dT)\} \\ &\quad - (\sin\theta_0 \cdot \cos\theta_1 \cdot \cos\theta_3)/(\cos\theta_0 \cdot \cos\theta_2 \cdot \cos\theta_4) \\ &\quad \times (dn_r/dT) \\ &= \tan\theta_4 \cdot (1/n_r) \cdot (dn_r/dT) \\ &\quad - \lambda \cdot (d\theta_4/d\lambda) \\ &\quad \times \{(1/d)(dd/dT) + (1/n_a)(dn_a/dT)\} \\ &\quad - (\sin\theta_i \cdot \cos\theta_1 \cdot \cos\theta_3)/(\cos\theta_0 \cdot \cos\theta_2 \cdot \cos\theta_4) \\ &\quad \times (1/n_r) \cdot (dn_r/dT) \end{aligned} \qquad (29)$$

となる。

【0044】ここで、媒質の温度係数である”$(1/n_r) \cdot (dn_r/dT)$”は通常用いる媒質であれば正の値である。この時、

$$d\theta_4/d\lambda < 0$$

$$(1/d)(dd/dT) > 0$$

$$(1/n_a)(dn_a/dT) > 0$$

$$0^\circ < \theta_j < 90^\circ \qquad (j = i, 1, 2, 3, 4)$$

であるので、式(29)の第1項及び第2項は正の値である。

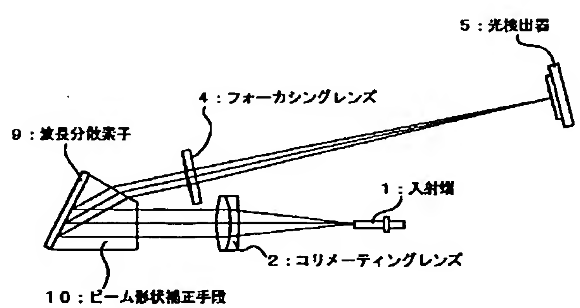
【0045】一方、式(29)の第3項は負の値であるので、波長分散素子9とビーム形状補正手段10を一体化した場合の温度係数”$d\theta_4/dT$”を低減することができる。

【0046】また、式(29)における第1項はビーム形状補正手段10の出射面での屈折、第2項は波長分散素子9での回折、そして、第3項はビーム形状補正手段10の入射面での屈折によるものである。

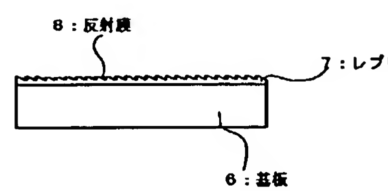
【0047】この結果、波長分散素子9とビーム形状補正手段10を一体化した場合の温度係数をビーム形状補

正手段１０の入射面での屈折による温度係数で補正することにより、温度特性の改善が可能になる。
【００４８】一方、図３（Ｂ）の場合には式（２９）の第３項の符号が”－”から”＋”に変わるため温度係数”$d\theta_4/dT$”を大きくする項だけになってしまう。但し、媒質の温度係数である”$(1/n_r)\cdot(dn_r/dT)$”が負の値である媒質も存在するのでこのような媒質を用いることにより、温度係数”$d\theta_4/dT$”の低減も可能である。
【００４９】さらに、波長分解能を犠牲にすること無く小型化するためには回折格子の格子定数”ｄ”を小さくする必要があるが式（１）の右辺の上限は”２”であるので波長”λ”が決まると格子定数”ｄ”の最小値もまた自ずと求まってしまう。
【００５０】これに対して、回折格子等の波長分散素子９とプリズム等のビーム形状補正手段１０とを一体化した場合には式（１２）～式（１４）に示すように媒質の屈折率”ｎ”と格子定数”ｄ”との積となるので屈折率”ｎ”が大きくなるほど格子定数”ｄ”を小さくできる。
【００５１】言い換えれば、プリズム等のビーム形状補正手段１０の媒質の屈折率を大きくすることにより、波長分解能を犠牲にすることなく分光装置の小型化が可能になる。
【００５２】なお、波長分散素子９である回折格子表面のレプリカにプリズム等のビーム形状補正手段１０を設けが、特にプリズム等のビーム形状補正手段ではなく何らかのウィンドウを回折格子表面に設ければ耐湿性の改善を図ることが可能である。
【００５３】また、波長分散素子９とビーム形状補正手段１０を一体化する場合には波長分散素子９をビーム形状補正手段１０に貼りつけても、ビーム形状補正手段１０に直接形成しても構わない。
【００５４】また、波長分散素子としては回折格子を例示したが、回折格子のみならずエシュレ格子であっても同様に用いることが可能である。
【００５５】
【発明の効果】以上説明したことから明らかなように、本発明によれば次のような効果がある。請求項１，２及び請求項３の発明によれば、回折格子表面のレプリカにはプリズム等のビーム形状補正手段が設けられるので耐湿性が改善されることになる。
【００５６】また、波長分散素子の出射光をビーム形状補正手段で補正することにより、波長分散素子の出射角の余弦成分に起因する非線形性がビーム形状補正手段の余弦成分による非線形性で補償されることになり、波長分散特性の平坦化が可能になる。
【００５７】また、波長分散素子とビーム形状補正手段を一体化した場合の温度係数をビーム形状補正手段の入射面での屈折による温度係数で補正することにより、温度特性の改善が可能になる。
【００５８】さらに、プリズム等のビーム形状補正手段の媒質の屈折率を大きくすることにより、波長分解能を犠牲にすることなく分光装置の小型化が可能になる。
【図面の簡単な説明】
【図１】本発明に係る分光装置の一実施例を示す構成図である。
【図２】波長分散素子及びビーム形状補正手段での光路を説明する説明図である。
【図３】波長分散素子及びビーム形状補正手段での光路を説明する説明図である。
【図４】従来の分光装置の一例を示す構成図である。
【図５】波長分散素子である回折格子の一例を示す構造断面図である。
【図６】分光装置の一設計例を示す表である。
【図７】各波長に対する出射角を示す表である。
【符号の説明】
１　入射端
２　コリメーティングレンズ
３，９　波長分散素子
４　フォーカシングレンズ
５　光検出器
６　基板
７　レプリカ
８　反射膜
１０　ビーム形状補正手段

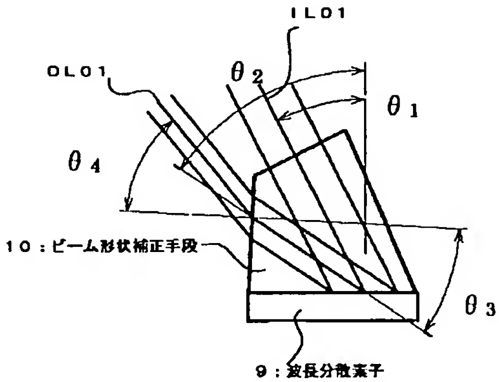
【図１】



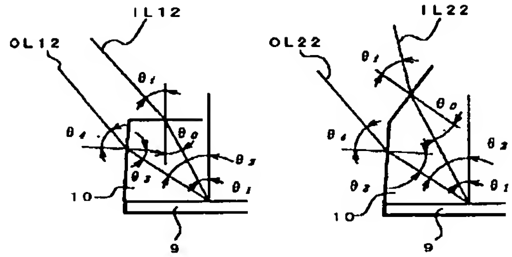
【図５】



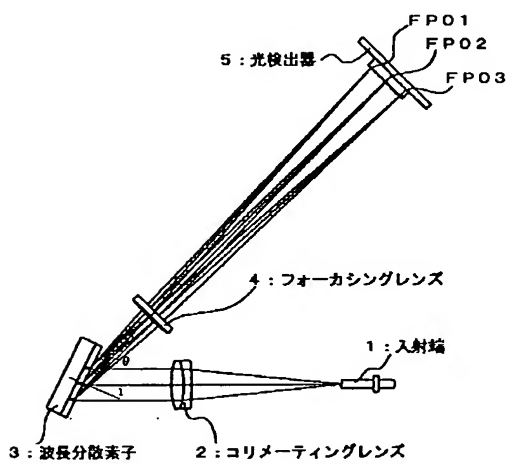
【図2】



【図3】



【図4】



【図6】

波長範囲	1531～63nm
格子定数	1．11×10^{-6}
入射角	26．39°
次数	1
フォーカシングレンズの距離	103．5mm
フォトダイオードアレイの間隔	50μm

【図7】

波長［nm］	出射角［°］
1531	68．97
1547	71．4
1563	74．19

PAT-NO: JP02000321135A

DOCUMENT-IDENTIFIER: JP 2000321135 A

TITLE: SPECTROMETER

PUBN-DATE: November 24, 2000

INVENTOR-INFORMATION:

NAME	COUNTRY
SUZUKI, YASUYUKI	N/A
SANPEI, YOSHIHIRO	N/A
OKADA, YORIKI	N/A

ASSIGNEE-INFORMATION:

NAME	COUNTRY
YOKOGAWA ELECTRIC CORP	N/A

APPL-NO: JP11126760

APPL-DATE: May 7, 1999

INT-CL (IPC): G01J003/18

ABSTRACT:

PROBLEM TO BE SOLVED: To realize a spectrometer in which moisture resistance and temperature characteristics can be enhanced.

SOLUTION: The spectrometer comprises a lens 2 for collimating an incident light, a wavelength dispersion element 9, a beam shape correcting means 10 integrated with the wavelength dispersion element 9 and directing the collimated light from the collimating lens 2 to the wavelength dispersion element 9 thus refracting the outgoing light beam from the wavelength dispersion element 9, a lens 4 for focusing the output from

light beam from the
beam shape correcting means 10, and a photodetector 5 for
detecting the output
light beam from the focus lens 4.

* NOTICES *

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] the spectrum with which the wavelength dispersion component was used for this invention -- equipment -- being related -- the spectrum which can improve opposite environment nature and the temperature characteristic especially -- it is related with equipment.
[0002]
[Description of the Prior Art] the conventional spectrum -- with equipment, light is separated and detected for every wavelength by receiving with a photodetector the light by which wavelength dispersion was carried out by irradiating incident light at the diffraction grating which is a wavelength dispersion component.
[0003] such [drawing 4] a conventional spectrum -- it is the block diagram showing an example of equipment. As for the incidence edge where, as for 1, incidence of the output light of the light source or the outgoing radiation light from an optical fiber is carried out from the exterior, and 2, in drawing 4 , a collimating lens and 3 are the photodetectors with which wavelength dispersion components, such as a diffraction grating, and 4 used the focusing glass, and 5 used the photodiode array etc.
[0004] The output light from the incidence edge 1 is changed into parallel light by the collimating lens 2, and incidence is carried out to the wavelength dispersion component 3. It is condensed by the focusing glass 4 and incidence of the light by which wavelength dispersion was carried out from the wavelength dispersion component 3 is carried out to a photodetector 5.
[0005] Moreover, drawing 5 is the structure section Fig. showing an example of the diffraction grating which is the wavelength dispersion component 3. The replica of the resin with which many grids for the substrate in which 6 is formed with glass etc. in drawing 5 , and 7 to produce diffraction were prepared, and 8 are metaled reflective film.
[0006] On a substrate 6, the replica 7 of the resin with which many grids were prepared is formed, and it is covered with the front face of a replica 7 with the reflective film 8.
[0007] Here, actuation of the conventional example shown in drawing 4 is explained. Since an angle of diffraction changes with the wavelength, outgoing radiation of the light by which incidence was carried out to the wavelength dispersion components 3, such as a diffraction grating, is carried out in the direction different, respectively as the diffracted light, and it is condensed by each photo detector which constitutes a photodetector 5 by the focusing glass 4, respectively.
[0008] For example, the light of different wavelength is condensed in the photo detector located in "FP01", "FP02", and "FP03" among drawing 4 . In the conventional example shown in drawing 6 , since it is not necessary to rotate the wavelength dispersion components 3, such as a diffraction grating, it excels in rapidity and dependability.
[0009] for example, the degree of the diffraction of the wavelength dispersion components 3, such as a diffraction grating, -- the lattice constant of "m" and the wavelength dispersion components 3, such as a diffraction grating, -- "d", the incident angle to the wavelength dispersion components 3, such as a diffraction grating, and an outgoing radiation angle -- "i" and "theta", and wavelength -- "lambda", then

mlambda/d=sini+sintheta (1)
It becomes.
[0010] a spectrum as shown in drawing 4 -- when equipment is designed so that the narrow wavelength range may be treated like a WDM (Wavelength Division Multiplxing: wavelength multiple signal) system monitoring monitor, as compared with the focal distance of a focusing glass 4, the breadth of the optical path by wavelength dispersion becomes small, and the location and outgoing radiation angle of each component when use the photograph DAO door lei of one-dimensional array as a photodetector 5 become proportionality mostly.
[0011] However, the relation between wavelength and an outgoing radiation angle is dlambda/dtheta|i= (d/m) andcostheta which differentiated the formula (1). (2)
It becomes.
[0012] As shown in a formula (2), wavelength and a distributed angle will be proportional to the cosine of an outgoing radiation angle. this outgoing radiation angle -- a spectrum -- it can ask from a formula (1) using the lattice constant of the wavelength range of equipment, and the diffraction grating to be used, the focal distance of the FOKANSHINGU lens 4, etc.
[0013] such [drawing 6] a spectrum -- it is the table showing the example of 1 design of equipment, and drawing 7 is the table showing the outgoing radiation angle over each wavelength. in this case -- for example, -- " -- lambda -- = -- 1.55 -- [-- mu -- m --] -- " -- " -- a grid -- a number -- 900 -- [-- l -- /-- mm --] -- " -- and -- " -- 32 -- [-- nm --] -- " -- wavelength -- the range -- " -- 190 -- a piece -- " -- a photo detector -- then -- an average -- wavelength dispersion -- " -- 32 -- /-- 190 -- = -- about -- 0.17 -- [-- nm --] -- " -- becoming .
[0014] Moreover, if a focal distance f2 uses the thing of "50mm" as a collimating lens 2, the use field of the wavelength dispersion components 3, such as a diffraction grating, will be decided by the incident angle to the numerical aperture and the wavelength dispersion component 3 of the incidence edge 1, and will serve as an ellipse of the major axis of "11.1 [mm]."
[0015] the "theoretical resolution by Reileigh criteria -- since lambda/delta lambda" can be found" in the total slot number of the diffraction grating which is the wavelength dispersion component 3 -- 900x11.1**10000 (3)
Come out and it is. Lambda/delta lambda=1.55/deltalambda=10000 (4)
thereforedeltalambda=1.55 / 10000**0.15 [nm] (5)
It becomes.
[0016] Moreover, magnitude"omega" of image formation is the ratio of "3.4 [mm]", and the radius of light and focal distance which carry out incidence to a focusing glass 4 about the beam width of the diffracted light "NA", then omega=2andlambda/(pi-NA) (6)
It becomes.
[0017] The magnitude of a formula (6) to image formation is set to "0.2 [nm]" by the product with average wavelength dispersion"0.17nm/50micrometer" in "59 [mum]", and is a little less than theoretical resolution "deltalambda=0.15[nm]", and resolution serves as a suitable value.
[0018]
[Problem(s) to be Solved by the Invention] However, as shown in a formula (5) in the conventional example shown in drawing 4 , since it was dependent on the area size used with the wavelength dispersion components 3, such as a diffraction grating, in order to raise resolution, resolution is difficult to make small the optic which constitutes optical system, and had the trouble which the miniaturization of equipment said was difficult.
[0019] Moreover, the replica part of the diffraction grating which is the wavelength dispersion component 3 as shown in drawing 5 had the trouble said that opposite humidity is inferior as compared with an optic like the lens currently formed with glass etc., or prism.
[0020] Furthermore, if the lattice constant of "T" and a diffraction grating is set to "D" and it sets [the refractive index of air] wavelength to "lambda" for "nair" and temperature in using in air the diffraction grating shown in drawing 5 , it is the temperature characteristic of the outgoing radiation angle"theta". d theta/dT = -lambda/(D-costheta) x{dD/(D-dT)

+(1/nair)(dnair/dT)} (7)
It becomes.
[0021] In a formula (7), the 1st term in "{}" is the coefficient of linear expansion of the diffraction grating which is the wavelength dispersion component 3, and the 2nd term is the temperature coefficient of the refractive index of air. Moreover, temperature coefficient of wavelength dlambda/dT=
(dlambda/dtheta) - (d theta/dT)
= -lambda-{dD/(D-dT)
+(1/nair)(dnair/dT)} (8)
It becomes.
[0022] For example, if the diffraction grating which set wavelength to "1.55 micrometers" and used Pyrex glass as the substrate 6 is used in air, the temperature coefficient will become "about 3.7 pm (s)/degree C." namely, a spectrum -- the wavelength property of equipment had the trouble referred to as having the temperature characteristic resulting from the coefficient of linear expansion of the ingredient of a diffraction grating. therefore, the spectrum [the technical problem which this invention tends to solve] which can improve opposite humidity and the temperature characteristic -- it is in realizing equipment.
[0023]
[Means for Solving the Problem] In order to attain such a technical problem, among this inventions invention according to claim 1 the spectrum using a wavelength dispersion component -- in equipment with the collimating lens which makes incident light parallel light The shape-of-beam amendment means which is united with a wavelength dispersion component and this wavelength dispersion component, carries out incidence of said parallel light from said collimating lens to said wavelength dispersion component, and the outgoing radiation light of said wavelength dispersion component is made refracted, and carries out outgoing radiation, By having had the focusing glass which condenses the output of this shape-of-beam amendment means, and the photodetector which detects the output light of this focusing glass, since shape-of-beam amendment means, such as prism, are formed in the replica on the front face of a diffraction grating, moisture resistance will be improved.
[0024] Moreover, by amending the outgoing radiation light of a wavelength dispersion component with a shape-of-beam amendment means, the nonlinearity resulting from the cosine component of the outgoing radiation angle of a wavelength dispersion component will be compensated with the nonlinearity by the cosine component of a shape-of-beam amendment means, and flattening of a wavelength dispersion property becomes possible. Moreover, an improvement of the temperature characteristic is attained by amending the temperature coefficient at the time of unifying a wavelength dispersion component and a shape-of-beam amendment means with the temperature coefficient by refraction by the plane of incidence of a shape-of-beam amendment means. furthermore, the thing for which the refractive index of the medium of shape-of-beam amendment means, such as prism, is enlarged -- wavelength -- without it sacrifices resolution -- a spectrum -- the miniaturization of equipment is attained.
[0025] the spectrum whose invention according to claim 2 is invention according to claim 1 -- in equipment, when said wavelength dispersion means is a diffraction grating, since shape-of-beam amendment means, such as prism, are formed in the replica on the front face of a diffraction grating, moisture resistance will be improved. Moreover, by amending the outgoing radiation light of a wavelength dispersion component with a shape-of-beam amendment means, the nonlinearity resulting from the cosine component of the outgoing radiation angle of a wavelength dispersion component will be compensated with the nonlinearity by the cosine component of a shape-of-beam amendment means, and flattening of a wavelength dispersion property becomes possible. Moreover, an improvement of the temperature characteristic is attained by amending the temperature coefficient at the time of unifying a wavelength dispersion component and a shape-of-beam amendment means with the temperature coefficient by refraction by the plane of incidence of a shape-of-beam amendment means. furthermore, the thing for which the refractive index of the medium of shape-of-beam amendment means, such as prism, is enlarged -- wavelength -- without it sacrifices resolution -- a spectrum -- the miniaturization of

equipment is attained.
[0026] the spectrum whose invention according to claim 3 is invention according to claim 1 -- in equipment, when said shape-of-beam amendment means is prism, since shape-of-beam amendment means, such as prism, are formed in the replica on the front face of a diffraction grating, moisture resistance will be improved. Moreover, by amending the outgoing radiation light of a wavelength dispersion component with a shape-of-beam amendment means, the nonlinearity resulting from the cosine component of the outgoing radiation angle of a wavelength dispersion component will be compensated with the nonlinearity by the cosine component of a shape-of-beam amendment means, and flattening of a wavelength dispersion property becomes possible. Moreover, an improvement of the temperature characteristic is attained by amending the temperature coefficient at the time of unifying a wavelength dispersion component and a shape-of-beam amendment means with the temperature coefficient by refraction by the plane of incidence of a shape-of-beam amendment means. furthermore, the thing for which the refractive index of the medium of shape-of-beam amendment means, such as prism, is enlarged -- wavelength -- without it sacrifices resolution -- a spectrum -- the miniaturization of equipment is attained.
[0027]
[Embodiment of the Invention] The gestalt of operation of this invention is explained to a detail using a drawing below. the spectrum which drawing 1 requires for this invention -- it is the block diagram showing one example of equipment. In drawing 1 , 1, 2, 4, and 5 have attached the same sign as drawing 4 , 9 is wavelength dispersion components, such as a diffraction grating, and 10 is shape-of-beam amendment means, such as prism.
[0028] The output light from the incidence edge 1 is changed into parallel light by the collimating lens 2, and incidence is carried out to the wavelength dispersion components 9, such as a diffraction grating, through the shape-of-beam amendment means 10, such as prism. It is again condensed by the focusing glass 4 through the shape-of-beam amendment means 9, and incidence of the diffracted light from the wavelength dispersion components 10, such as a diffraction grating, is carried out to a photodetector 5.
[0029] Here, the example shown in drawing 1 is explained using drawing 2 . Drawing 2 is an explanatory view explaining the optical path in the wavelength dispersion component 9 and the shape-of-beam amendment means 10, among drawing 2 , "IL01" is incident light and "OL01" is outgoing radiation light. Moreover, since fundamental actuation is the same as that of the conventional example shown in drawing 6 , explanation is omitted.
[0030] Since shape-of-beam amendment means, such as prism, are formed in the replica of the front face of a diffraction grating as shown in drawing 5 , moisture resistance will be improved.
[0031] moreover, a spectrum -- if the wavelength dispersion property of equipment is searched for by the formula (2) and transforms this -- dlambda=(d/m) andcostheta-dtheta (9)
supposing the photo detectors which constitute a next door and a photodetector 5 are regular intervals, it will originate in a cosine component (costheta) and an ununiformity will arise in wavelength dispersion -- things -- ** In other words, nonlinearity exists.
[0032] On the other hand, the formula of refraction is n1, sinphi=n2, andsinpsi, when "n1" and "n2", an incident angle, and an outgoing radiation angle are set to "phi" and "psi" for the refractive index of a medium. (10)
When it differentiates by the next door and "phi", they are n1, cosphi-dphi=n2, andcospsi-dpsi. (11)
It becomes.
[0033] As shown in a formula (11), it depends also for angle of refraction on a cosine component. Therefore, it becomes possible to compensate the nonlinearity resulting from the cosine component of the outgoing radiation angle of the wavelength dispersion component 9 with the nonlinearity by the cosine component of refraction (shape-of-beam amendment means 10).
[0034] drawing 2 -- setting -- the angle of incidence and outgoing radiation angle of the wavelength dispersion component 9 -- "theta 1", "theta2 "angle-of-incidence [of the shape-of-beam amendment means 10] and outgoing radiation angle" theta3", and "theta 4" -- carrying out -- the refractive index of the shape-of-beam amendment means 10 -- "n" and wavelength -- "lambda", then

sintheta1+sintheta2=lambda/(n-d) (12)
dtheta2/d=-dtheta3/dlambda (13)
n-sintheta3=sintheta4 (14)
It becomes.
[0035] And average wavelength dispersion is obtained by differentiating and arranging a formula (14) from a formula (12). dtheta4/dlambda-costheta3/(d-costheta2 and costheta4) (15)
It becomes.
[0036] Furthermore, a formula (15) is transformed. d2theta4/dlambda2=(dtheta4/dlambda) 2 x {sintheta4 / costheta4 -(sintheta2 and costheta4)/(n-costheta2 and costheta3)
- sintheta3andcostheta4/(n-cos 2theta3)} (16)
It becomes.
[0037] Since it is "d2theta4/d2=0" here in order for this property to be linearity, a formula (16) is transformed, and it is tantheta3/(1-n2, sin 2theta3).
= n-tantheta2/(n2-1) (17)
It becomes.
[0038] Consequently, by amending the outgoing radiation light of the wavelength dispersion component 9 with the shape-of-beam amendment means 10, the nonlinearity resulting from the cosine component of the outgoing radiation angle of the wavelength dispersion component 9 will be compensated with the nonlinearity by the cosine component of the shape-of-beam amendment means 10, and flattening of a wavelength dispersion property becomes possible.
[0039] moreover, the relative value [as opposed to / since a temperature coefficient exists also in the refractive index of media, such as prism which is the shape-of-beam amendment means 10, / the air of a medium] of a temperature coefficient -- "nr "absolute value" na" -- carrying out -- the refractive index of air -- "nair" -- then -- nr=na/nair (18)
(1/nr)(dnr/dT)=(1/na)(dna/dT) -(1/nair)(dnair/dT) (18)
It is expressed nair**1 and nr**na.
[0040] The temperature coefficient at the time of unifying the wavelength dispersion component 9 and the shape-of-beam amendment means 10 is explained using drawing 3 . Drawing 3 is an explanatory view explaining the optical path in the wavelength dispersion component 9 and the shape-of-beam amendment means 10. the inside of drawing 3 -- "IL12" and "IL22" -- the inside of incident light and drawing 3 -- "OL12" and "OL22" -- outgoing radiation light -- it is -- drawing 3 (A) -- incident light -- the case where "IL21" carries out clockwise rotation refraction to the drawing 3 front face on the front face of the shape-of-beam amendment means 10 -- drawing 3 (B) -- incident light -- when "IL22" carries out counterclockwise rotation refraction to the drawing 3 front face on the front face of the shape-of-beam amendment means 10, ** is shown, respectively.
[0041] In the case of drawing 3 (A), it is incident light"IL12 (or). the angle of incidence over the shape-of-beam amendment means 10 of "IL22"" -- the incident light of "thetai" and the shape-of-beam amendment means 10 -- " -- IL12 (or) the angle of refraction of "IL22"" -- "theta0 "incident angle to wavelength dispersion component 9" theta1", and the angle of diffraction in the wavelength dispersion component 9 -- "theta 2" and outgoing radiation light -- " -- OL12 (or) " -- OL22 -- ""incident angle of the diffracted light to outgoing radiation side of shape-of-beam amendment means 10 by which outgoing radiation is carried out" theta3", and the angle of refraction in said outgoing radiation side -- "theta 4", then nr-sintheta0= -- sinthetai -- (19)
dtheta0=dtheta1 (20)
sintheta1+sintheta2=lambda/(d-na) (21)
dtheta2=-dtheta3 (22)
nr-sintheta3=sintheta4 (23)
It becomes.
[0042] If a formula (19) - a formula (23) are differentiated by temperature"T" (dnr/dT) -sintheta0+nr-costheta0 and (dtheta0/dT) =0 (24)
dtheta0-/dT=d theta1/dT (25)

costheta1and(dtheta1/dT) +costheta2- (dtheta2/dT) =-lambda/(d-na) x {(1/d) (dd/dT)+ (1/na) (dna/dT)} (26)
dtheta2/dT=-dtheta3/dT (27)
(dnr/dT) -sintheta3+nr-costheta3- (dtheta3/dT) =costheta4- (dtheta4/dT) (28)
It becomes.
[0043] If a formula (24) - a formula (28) are arranged dtheta4-/dT= (sintheta3/costheta4) (dnr/dT) + nr-costheta3/costheta4 (dtheta3/dT) = sintheta3/costheta4 (dnr/dT) - nr-costheta3/costheta4 x[-lambda/(d-na) (1/costheta2) x {(1/d) (dd/dT)+ (1/na) (dna/dT)} - costheta1-/costheta2(dtheta1/dT)] = (sintheta3/costheta4) (dnr/dT) + lambda-cos theta3/(d-costheta2 and costheta4) x {(1/d) (dd/dT)+ (1/na) (dna/dT)} - sintheta0, costheta1, andcostheta3/(costheta0, costheta2, and costheta4) x (dnr/dT) = tantheta4 -(1/nr)- (dnr/dT) - lambda- (dtheta4/dlambda) x {(1/d) (dd/dT)+ (1/na) (dna/dT)} -(sinthetai-cos theta1 and costheta3)/(costheta0, costheta2, and costheta4) x (1/nr) and (dnr/dT) (29)
It becomes.
[0044] Here, if "(1/nr) -(dnr/dT)" which is the temperature coefficient of a medium is a usually used medium, it is a forward value. At this time, it is dtheta4/dlambda<0(1/d) (dd/dT) > 0 (1/na)> (dna/dT) 00 degree<thetaj<90 degree. (j=i, 1, 2, 3, 4)
It comes out, and since it is, the 1st term and the 2nd term of a formula (29) are a forward value.
[0045] on the other hand -- a formula -- (-- 29 --) -- the -- three -- a term -- negative -- a value -- it is -- since -- wavelength dispersion -- a component -- nine -- the shape of beam -- amendment -- a means -- ten -- having unified -- a case -- a temperature coefficient -- " -- d -- theta -- four -- /-- dT -- " -- it can decrease .
[0046] Moreover, according to [the 1st term in a formula (29) / the 3rd term / refraction / by the plane of incidence of the shape-of-beam amendment means 10] according to diffraction with the wavelength dispersion component 9 in the refraction in respect of the outgoing radiation of the shape-of-beam amendment means 10, and the 2nd term.
[0047] Consequently, an improvement of the temperature characteristic is attained by amending the temperature coefficient at the time of unifying the wavelength dispersion component 9 and the shape-of-beam amendment means 10 with the temperature coefficient by refraction by the plane of incidence of the shape-of-beam amendment means 10.
[0048] On the other hand, since the sign of the 3rd term of a formula (29) changes from "-" at "+" in the case of drawing 3 (B), it will become only the term which enlarges temperature coefficient"dtheta4/dT." However, since the medium whose "(1/nr) -(dnr/dT)" which is the temperature coefficient of a medium is a negative value also exists, reduction of temperature coefficient"dtheta4/dT" is also possible by using such a medium.
[0049] furthermore, wavelength -- in order to miniaturize without sacrificing resolution -- the lattice constant of a diffraction grating -- although it is necessary to make "d" small, since the upper limit of the right-hand side of a formula (1) is "2" -- wavelength -- if "lambda" is decided -- a lattice constant -- the minimum value of "d" will also be able to be found naturally.
[0050] on the other hand, when the wavelength dispersion components 9, such as a diffraction grating, and the shape-of-beam amendment means 10, such as prism, are unified, it is shown in a formula (12) - a formula (14) -- as -- the refractive index of a medium -- since it becomes a product with "n" and lattice constant "d" -- a refractive index, so that "n" becomes large -- a lattice constant -- "d" can be made small.
[0051] in other words enlarging the refractive index of the medium of the shape-of-beam amendment means 10, such as prism, -- wavelength -- without it sacrifices resolution -- a spectrum -- the miniaturization of equipment is attained.
[0052] In addition, it is possible ****** and to aim at a damp-proof improvement for the shape-of-beam amendment means 10, such as prism, if not a shape-of-beam amendment means but some windows, such as prism, are especially established in a diffraction-grating front face on the replica on the front face of a diffraction grating which is the wavelength dispersion component 9.
[0053] Moreover, in unifying the wavelength dispersion component 9 and the shape-of-beam

amendment means 10, even if it sticks the wavelength dispersion component 9 on the shape-of-beam amendment means 10, it does not matter even if it forms in the shape-of-beam amendment means 10 directly.
[0054] Moreover, although the diffraction grating was illustrated as a wavelength dispersion component, it is possible not only a diffraction grating but to use similarly, even if it is an ESHURE grid.
[0055]
[Effect of the Invention] According to this invention, there is the following effectiveness so that clearly from having explained above. According to invention of claims 1 and 2 and claim 3, since shape-of-beam amendment means, such as prism, are formed in the replica on the front face of a diffraction grating, moisture resistance will be improved.
[0056] Moreover, by amending the outgoing radiation light of a wavelength dispersion component with a shape-of-beam amendment means, the nonlinearity resulting from the cosine component of the outgoing radiation angle of a wavelength dispersion component will be compensated with the nonlinearity by the cosine component of a shape-of-beam amendment means, and flattening of a wavelength dispersion property becomes possible.
[0057] Moreover, an improvement of the temperature characteristic is attained by amending the temperature coefficient at the time of unifying a wavelength dispersion component and a shape-of-beam amendment means with the temperature coefficient by refraction by the plane of incidence of a shape-of-beam amendment means.
[0058] furthermore, the thing for which the refractive index of the medium of shape-of-beam amendment means, such as prism, is enlarged -- wavelength -- without it sacrifices resolution -- a spectrum -- the miniaturization of equipment is attained.

[Translation done.]